Trends in the Freeze-Thaw Cycles of High Northern Latitude Ecosystems from 1988 to 2002

Nicole V. Smith
Ph.D. Candidate
Department of Environmental Science and Engineering, California Institute of Technology
(626) 395-6895
nicolev@gps.caltech.edu

Key Words: global change, remote sensing, global carbon cycle, boreal ecosystems, tundra ecosystems

In boreal and tundra ecosystems, the freeze state of soils limits rates of both soil respiration and photosynthesis. Here we develop a technique to identify the timing of freeze and thaw transitions of high northern latitude land areas using satellite data from the Scanning Multichannel Microwave Radiometer (SMMR) and Special Sensor Microwave/Imager (SSM/I). Our results indicate that spring thaw advanced in tundra (-3.3 ± 1.8 days/decade) and larch biomes (-4.5 ± 1.8 days/decade) in Eurasia over the period 1988-2002. Fall freeze was delayed in evergreen conifer forests of North America by 3.1 ± 1.2 days/decade and led in part to a lengthening of the growing season by 5.1 ± 2.9 days/decade. The growing season length in North American tundra also increased significantly (5.4 ± 3.1 days) during this period. Despite the advancing thaw in Eurasian larch forests, the growing season length did not increase in this biome because the fall freeze concurrently advanced by 5.4 ± 2.1 days/decade leading to a forward shift in the growing season. Thaw timing was negatively correlated with surface air temperatures in the spring, whereas freeze timing was positively correlated with surface air temperatures in the fall, suggesting that surface air temperature is one of several factors that determines the timing of soil thaw and freeze. The high spatial resolution, frequent temporal coverage, and duration of the SMMR and SSM/I satellite records makes them suitable for rigorous time series analysis and change detection in northern terrestrial ecosystems.

These data will be useful as a constraint on both soil respiration and plant photosynthesis. They provide a new and independent metric of ecosystem change since 1988, and have important consequences for ecosystem function and the global carbon cycle.